

# Impacts of the Covid-19 pandemic on the South African water sector

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An analysis of the impacts of the Covid-19 pandemic on the South African water sector is presented. The study identified and focused on three main themes: water revenue collection, water service delivery, and water sector operations. The Covid-19 pandemic negatively impacted these aspects and exacerbated pre-existing problems in the water provision landscape of South Africa. Business continuity management was identified as a top priority for water sector institutions in South Africa to ensure the continued provision of critical water services. In-depth case study research is recommended to establish how water sector institutions in South Africa dealt with the Covid-19 pandemic and how this can inform their disaster preparedness and management going forward.

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## INTRODUCTION

Prior to the Covid-19 pandemic, which began as a zoonotic infection in Wuhan, China, and was declared a global pandemic on 11 March 2020, the global water sector was impacted by five main factors (Cucinotta and Vanelli, 2020; IFC, 2020). These were global warming, the increasing number of people who live in areas facing water stress, rapid urbanisation, megacity emergence, and aging infrastructure (IFC, 2020). In addition, countries across the world were affected by sudden and unforeseen shifts in water consumption and challenges in water supply, and the situation was aggravated by a rapidly growing world population. These pre-existing challenges characterising the global water sector were amplified by the effects of the Covid-19 pandemic. This highlighted the need to recognise water access as a public health priority and calls for revision of disaster preparedness and management policies within the water and sanitation sector (Sowby, 2020; Renukappa et al., 2021). The Covid-19 pandemic has emphasised the need for improved water resource management and water infrastructure, more refined emergency response planning by water utilities and the need for the development of resilient water infrastructure policies (Berglund et al., 2021; Sowby and Lunstad, 2021). Prioritising equitable access to water and sanitation as a public health priority following the Covid-19 pandemic is particularly relevant in the South African context, given the plethora of challenges the country was already facing prior to the pandemic and which continue to characterise its water sector (Meissner et al., 2019). These challenges include the provision of adequate water and sanitation services to informal and rural settlements (Hara et al., 2020), the effects of failing and dysfunctional wastewater infrastructure (Mudombi and Montmasson-Clair, 2020), country-wide and regional droughts (Mahlalela et al., 2020), high amounts of non-revenue water levels in municipalities (~41%) due to leakages and non-payment for services (Mudombi and Montmasson-Clair, 2020), poor financial management (AGSA, 2021), and a rising demand for water supply and sanitation due to an expanding population.

While much is known about the precarious state of the South African water sector prior to the Covid-19 pandemic, it is also critically important to reflect on the impacts of the pandemic on this sector. The authors of this short communication offer some insights in this regard and present reflections on the way forward required for the South African water sector to deal with future challenges.

## METHODS

A literature search was conducted on Google, Google Scholar, Web of Science and Scopus to identify key literature on the impact of Covid-19 on the South African water sector, using the search terms 'Covid-19' AND 'water' AND 'South Africa'. The resulting literature (which included peer-reviewed and popular articles and news and government reports) was reviewed and relevant information was distilled into a series of themes and sub-themes.

In addition, the authors held a workshop in March 2022 with a South African water utility to discuss the impact of Covid-19 on water utilities in South Africa. The workshop provided insights into how the water utility addressed the challenges and impacts of the Covid-19 pandemic and reflected on lessons learned from the utility's management of the pandemic. The outcomes of this workshop are discussed where relevant.

## RESULTS AND DISCUSSION

Three main themes were identified: the impact that Covid-19 had on water revenue collection by water services authorities, the impact of the pandemic on water service delivery, and the impact on water sector operations. These three themes and their sub-themes are discussed and unpacked in this paper.

## **Theme 1: Impacts of the Covid-19 pandemic on water revenue collection by water services authorities**

Water and wastewater treatment systems play a vital role for community and economic development (Gude and Muire, 2021). A report prepared for the American Water Works Association (AWWA) and the Association of Metropolitan Water Agencies (AMWA) estimated the financial impacts of the Covid-19 crisis on drinking water utilities in the United States to be approximately 13.9 billion USD. This represents a net financial impact of 16.9% on the drinking water sector. These impacts are due to loss of income from industrial customers, increases in residential consumption, anticipated revenue loss due to non-payment from customers owing to high unemployment rates, and lower customer base growth (AWWA and AMWA, 2020). Many water utilities have experienced reduced revenue and increased operational expenses as a result of the pandemic and have been compelled to operate outside of design conditions, with a diminished workforce (Spearing et al., 2020). Wastewater utilities are likely to experience the same impacts as drinking water utilities, with the overall impact of Covid-19 on the water and wastewater sector estimated to be more than 27 billion USD (AWWA and AMWA, 2020). South Africa would have been affected similarly and the first theme identified in this study shows how the already problematic situation in the country (regarding water use revenue collection prior to 2020) was further exacerbated by the Covid-19 pandemic.

### ***Water use revenue collection – the already precarious situation prior to the Covid-19 pandemic***

In South Africa the primary revenue source for municipalities is own revenue, with water-related income typically contributing 8% of the total revenue (AGSA, 2020). Factors limiting the ability of water services authorities (municipalities responsible for providing water services to end users) to collect water revenue include high non-revenue water resulting from leakages, water theft, unbilled consumption, and uncollected revenue. In addition, inefficient water management, poor budgeting practices and low revenue collection from municipal debtors are placing considerable financial pressure on the water sector (AGSA, 2020). In an era of economic austerity, the financial situation of many water services authorities in South Africa was already grim prior to the Covid-19 pandemic. Just over 25% of municipalities were estimated to be in such a critical financial position that there was significant concern regarding their continued operation and provision of services (AGSA, 2020).

The average debt collection period for all municipalities was reported to be 203 days instead of the typical 30-day period and the annual debt written off amounted to 36.35 billion ZAR in 2019 (AGSA, 2020). Late payments to municipalities result in cash-flow challenges for their suppliers (whose average creditors-payment period was 136 days); therefore suppliers and contractors may stop delivering their services or delays may be experienced. Municipalities also incur interest and penalties on late payments, which results in material financial losses (AGSA, 2020).

Furthermore, water services authorities are in a predicament as they are legally obligated to continue water service delivery regardless of remuneration received (AGSA, 2020). When municipal customers do not pay what they owe this puts additional strain on the cash flow of municipalities (DPME, 2020). This situation became considerably worse during the Covid-19 pandemic and was aggravated by major losses in revenue, mainly from industry, due to closures of businesses, stringent lockdown restrictions and poor debt collection rates resulting from the increasing unemployment rate and rising poverty levels (Ruiters, 2020). A case study on the extent to which Northern Cape local municipalities were affected by the Covid-19 pandemic

revealed that municipalities were struggling to collect overdue revenue prior to the start of the pandemic and that the pandemic intensified this tendency (Hints, 2022).

### ***The impact of substantially lower payment rates by customers during and after Covid-19***

The decision of water services authorities to temporarily suspend the collection of interest on arrears and their legal obligation to continue to provide water services to municipal customers regardless of defaults in payments further exacerbated their financial situation (DPME, 2020). In April 2020 alone, the City of Cape Town reported a one-third drop in income from customers at an estimated 900 million ZAR in outstanding rates and service payments. This shortfall in income likely had a negative impact on the City's available budget for water supply, maintenance, and infrastructural upgrades that are needed to meet future demand (WISA, 2020).

Those municipal customers still able to pay their accounts also experienced problems as some water services authorities in South Africa closed their customer offices during Covid-19 lockdowns and made use of digital customer services instead (Funke et al., 2022). This presented challenges as many South African municipal customers cannot easily access the Internet or are not computer literate. The International Benchmarking Network for Water and Sanitation collected data from water services authorities across the world and reported a reduction of 40% in revenue collection within the first months of the pandemic as most customers were unable to pay online or did not have access to pay points (McDonald et al., 2020). This finding is also highly relevant to the South African context.

According to the Department of Planning, Monitoring and Evaluation (DPME) (2020), the debt recovery of municipalities was expected to further deteriorate in the 2020/21 financial year due to the continued economic downturn caused by the Covid-19 pandemic. In fact, the Auditor-General of South Africa (2020) estimated that only 103.76 billion ZAR (40%) of municipal revenue was recovered for the 2019/20 financial year. This is problematic because most water services authorities do not have sufficient cash reserves and are thus ill-equipped to deal with extended periods of reduced revenue (DPME, 2020).

### ***The impact of business closures on revenue***

The onset of the Covid-19 pandemic created significant disruptions to the economy and the operations of businesses, which in turn impacted the water revenue collected from these businesses. In late March 2020 the South African government introduced several stringent measures to attempt to curb the spread of Covid-19. One of these measures was the closure of businesses providing 'non-essential' goods and services. Not only did the municipalities face challenges such as collecting revenue from financially stressed residents, but also from game reserves and other public spaces that were forced to close (Hes, 2020). According to a survey conducted by Stats SA (2020), 46.4% of businesses indicated that they had closed temporarily in 2020 or had paused their trading activity. A knock-on effect of these closures was a reduced demand for goods in non-food-related manufacturing sectors, thereby also impacting the water use of such businesses and further shrinking the revenue collected from them (DPME, 2020). With revenue deteriorating, municipalities are more likely to default on bulk supply accounts (Hes, 2020).

## **Theme 2: Impacts of the Covid-19 pandemic on water service delivery**

The second theme deals with the problem of unacceptably low levels of water service delivery to poor and indigent communities

prior to 2020, the impacts on municipal budgets of emergency water and sanitation interventions during the Covid-19 pandemic, and the continued pressing need to prioritise equitable and efficient water service delivery in the future.

### ***Pre-existing water sector service delivery challenges***

According to the Socio-Economic Rights Institute of South Africa (SERI) (2018), in 2016 approximately 1 in 7 households in South Africa lived in informal dwellings (with the figure being 1 in 5 for metropolitan households), with the Housing Development Agency (HDA, 2012) noting that these figures are likely to under-represent the real expansion of informal settlements in South Africa. High settlement densities, insecurity of tenure, and complex community dynamics make planning and implementing standard infrastructure solutions in such circumstances difficult, if not impossible (SERI, 2018).

In addition to failing water services, communities are also often faced with sharing communal toilets and taps, placing residents at risk of contracting a range of diseases. For example, there are only 50 communal taps for the more than 60 000 residents of the Marikana informal settlement in Phillipi Township, while residents in Endlovi informal settlement, Khayelitsha, share 380 toilets between its 20 000 members (Hara et al., 2020).

One of the key reasons for poor service delivery is poor financial governance at municipal level. For the 2019/20 financial year, the Auditor-General of South Africa reported irregular expenditure at municipalities of 26 million ZAR, stating that the real number was likely to be even higher as just over a third of municipalities were disqualified based on disclosure completeness, or were still under investigation regarding the extent of irregular expenditure at the time when the report was released (AGSA, 2020).

### ***The provision of water and hygiene services in response to the Covid-19 pandemic***

The World Health Organisation (WHO) identified water, hygiene, and sanitation as crucial factors in the fight against the spread of Covid-19 (Hara et al., 2020; IFC, 2020). At the beginning of the pandemic, the Minister of Human Settlements, Water and Sanitation, Lindiwe Sisulu, announced that the Department would be providing emergency water and sanitation interventions to more than 2 000 vulnerable communities with limited or no access to water and sanitation services. This included public areas, overcrowded settlements, informal settlements, rural settlements, and water-scarce towns. The Department promised to supply communal water storage to communities with no formal water service, install hand-washing facilities in public areas such as taxi ranks, and to launch a health and hygiene campaign to raise awareness on hygiene practices to curb the spread of Covid-19 within these communities (Mudombi and Montmasson-Clair, 2020). Municipalities also rose to meet the need for additional services by distributing food parcels, soap and other hygiene products to the needy and by setting up additional water points (DPME, 2020).

South African municipalities rapidly expanded water service delivery during this time as disaster management regulations require provision of water and sanitation services to communities (Hes, 2020). The provision of these expanded services required supplementary resources, funding, and staff, resulting in 44% of municipalities having to adjust their budgets and redirect their expenditure. This led to budget cuts to administrative functions, subsistence and travel, and redirected funding from municipal service functions such as infrastructure operations and maintenance. Redirecting this funding from the already aging and poorly maintained infrastructure is expected to result in an increase in service delivery failures (DPME, 2020). In addition to

the funding provided by the Covid-19 relief fund, 1.5 billion ZAR originally earmarked for Municipal Infrastructure Grant funds was redirected to emergency water supply projects and as a result 74 of the 362 projects funded by these Municipal Infrastructure Grants failed to meet their intended project completion dates (DPME, 2020).

Despite efforts by the South African Government to provide emergency interventions during the pandemic, many communities continue to lack access to safe and reliable water and sanitation services. Chamberlain and Potter (2022) reiterate that the institutional capacity of both municipalities and the Department of Water and Sanitation (DWS) to provide water services, which was already compromised before the pandemic, has regressed further during the Covid-19 pandemic. This was the case because the budgetary resources available to facilitate the resumption of routine and sustainable municipal water services were severely affected by funding being redirected to other pandemic-related activities.

### ***Theme 3: The impact of the Covid-19 pandemic on water sector operations***

The third theme focuses on the changes that water sector institutions had to make during the pandemic to adhere to Covid-19 regulations and the impacts of these changes on their operations.

#### ***Adjusting 'business as usual' practices to adhere to Covid-19 regulations***

The biggest challenge presented by Covid-19 was that critical water sector operations, specifically treating water to potable standards and treating wastewater, had to continue despite disruption of the water sector workforce. This meant having to find ways for on-site operations to continue while minimising the spread of Covid-19 at the workplace (Funke et al., 2022). Some of the changes that were implemented in the water sector included remote working for staff who could perform their duties outside the office and working on a rotation-based schedule for those who needed to physically report to duty. Changes included limited site visits, no carpooling to sites, virtual meetings and conferences via online meeting platforms, revised risk assessments for sites to make them Covid-19 secure, social distancing in and outside of the workplace, and constantly practicing good hygiene and adopting digital technological tools to carry out daily functions (Renukappa et al., 2021). Some of these measures made it challenging to perform tasks and deliver work to the required standard.

#### ***Ensuring business continuity during the pandemic***

In this study business continuity is defined as the ability of an organisation to continue the delivery of services at acceptable levels during or following a disruptive incident. The Energy and Water Sector Education Training Authority (EWSETA) 'Water Sector Skills within a Covid-19 Context' virtual workshop that was held in partnership with the Department of Human Settlements (DHS), Department of Water and Sanitation (DWS), the Water Research Commission (WRC), and the Water Institute of Southern Africa (WISA) in August 2020 sought to unpack the impacts of Covid-19 on the water sector. During this workshop it was revealed that to cope with the rapidly changing environment, people in senior management had to immediately upskill themselves on topics such as risk and disaster management, leadership, and human resource management as well as agile project management. Remote working further exposed a plethora of challenges regarding skills shortages in the digital space and South Africa's lack of online and digital readiness (EWSETA, 2020). Disaster management regulations have



subjected municipalities to additional responsibilities, resulting in increased financial pressure. These included the setting up of isolation and quarantine facilities, regular sanitation and cleaning of public facilities and the provision of personal protective equipment (Hes, 2020).

Some of the common challenges faced by water utilities globally include maintaining social distancing, resource management, monitoring the health of employees, engaging with vendors to ensure that water system upgrades and repairs could be carried out and that chemical supplies were obtained for water treatment (Gude and Muire, 2021).

Challenges associated with working remotely included different Internet speeds, synthesizing data and information into digital formats (Renukappa et al., 2021), loadshedding, data costs, connectivity, access to devices, limited computer literacy (EWSETA, 2020) and coping with the mental health-related stresses caused by the pandemic (e.g. bereavements, anxiety, fear of stigma, loss of income, etc.) (Funke et al., 2022). In addition, it was challenging for management to ensure that staff at home maintained an acceptable level of productivity (DPME, 2020), as well as to manage people's off-site behaviour regarding adherence to measures to prevent the spread of Covid-19 (Funke et al., 2022).

Additional difficulties in ensuring business continuity included the shortage of parts and delayed shipments during the height of the pandemic, which also affected the ordering of chemicals. From an operations perspective, a further problem was presented by the July 2022 unrest in KwaZulu-Natal, which resulted in disruptions to the supply chain (Funke et al., 2022). In the United States a guidance document for business continuity planning specific to water utilities has been developed with the aim to maintain solid operations after any incident (WRF, EPA, AWWA, 2013). Development of similar guidance documents for the South African setting are also needed.

### Implementation and benefits of digital transformations

The Covid-19 pandemic, and the restrictions and regulations associated with it, placed a heavy reliance on digital technologies, such as digital meter readings or virtual site visits, to carry out daily work functions within water sector operations across the world. Virtual platforms were vital in ensuring that critical municipal functions such as council meetings and important dialogues continued (Hes, 2020). Renukappa et al. (2021) believe that the benefits experienced from the implementation of these technologies are greater now than ever before and are of the opinion that the pandemic has advanced digital transformation. The Bergrivier local municipality in the Western Cape used virtual platforms for public participation as soon as lockdown was put in place to ensure that the public had access to view and comment on draft documents, thereby showing the value of digital platforms (Hes, 2020).

Water sectors globally have increasingly made use of information and communication technology (ICT) tools in project collaboration and delivery since the start of the Covid-19 pandemic (Renukappa et al., 2021). A study done in the United Kingdom's water sector found that ICT tools were being used extensively during project delivery, from the commencement of the project to the operation of assets (Renukappa et al., 2021). In the South African context, it became necessary to ensure that all unit systems at water utilities continued functioning and that these could potentially be operated remotely from different locations. At some water utilities, simulation scenarios were run to ensure that operations could be carried out remotely if the pandemic became extremely severe (which turned out not to be the case in South Africa) (Funke et al., 2022).

## CONCLUSION

This short communication provides some interesting insights into challenges and opportunities faced by the South African water sector, particularly in respect of revenue collection, water service delivery and water sector operations.

A key lesson for the South African water sector based on its experiences during the Covid-19 pandemic is to adopt a proactive rather than reactive approach to the management of current and future challenges. This translates to addressing some of the persistent shortcomings regarding water use revenue collection as well as the continuing backlogs and inequities characterising water service delivery in South Africa. From a business continuity management perspective, there is a clear need for operations that have such plans in place and to conduct regular stress testing, both during and after a crisis, to determine whether the plans are sufficient or whether they need to be adjusted. At the same time, there is an urgent need to develop such plans for water sector institutions which do not yet have them in place.

Future research should focus on case studies of water services authorities or water utilities to come to a better understanding of the challenges faced by different institutions in the South African water sector and how they can adapt to better respond to similar challenges in future.

## AUTHOR CONTRIBUTIONS

Conceptualisation and methodology of the study, data collection, data analysis, interpretation of results, writing of the manuscript: Nikki Funke, Wouter le Roux, Lisa Schaefer.

Data collection, data analysis, interpretation of results, writing of the manuscript: Audrey de Wet and Ayanda Mafunda.

## REFERENCES

- AGSA (Auditor General of South Africa) (2020) Consolidated general report MFMA 2019–20. URL: <https://www.agsa.co.za/Reporting/MFMAReports/MFMA2019-2020.aspx> (Accessed 3 January 2023).
- AGSA (Auditor General of South Africa) (2021) Consolidated general report MFMA 2020–21. URL: <https://www.agsa.co.za/Reporting/MFMAReports/MFMA2020-2021.aspx> (Accessed 3 January 2023).
- AWWA and AMWA (American Water Works Association and Association of Metropolitan Water Agencies) (2020) The financial impact of the Covid-19 crisis on U.S. drinking water utilities. URL: [https://www.awwa.org/Portals/0/AWWA/Communications/AWWA-AMWA-COVID-Report\\_2020-04.pdf](https://www.awwa.org/Portals/0/AWWA/Communications/AWWA-AMWA-COVID-Report_2020-04.pdf) (Accessed 31 October 2023).
- BERGLUND EZ, THELEMAQUE N, SPEARING L, FAUST K, KAMINSKY J, SELA L, GOHARIAN E, ABOKIFA A, LEE J, KECK J and co-authors (2021) Water and wastewater systems and utilities: challenges and opportunities during the Covid-19 pandemic. *J. Water Resour. Plann. Manage.* **147** (5) 02521001. [https://doi.org/10.1061/\(ASCE\)WR.1943-5452.0001373](https://doi.org/10.1061/(ASCE)WR.1943-5452.0001373)
- CUCINOTTA D and VANELLI M (2020) WHO declares COVID-19 a pandemic. *Acta Biomed.* **91** (1) 157–160. <https://doi.org/10.23750/abm.v91i1.9397>.
- CHAMBERLAIN L and POTTER A (2022) An analysis of South Africa's provision of emergency water supply during the Covid-19 pandemic: accountability and expiration. *Potchefstroom Electron. Law J.* **25**. <https://doi.org/10.17159/1727-3781/2022/v25i0a9301>.
- DPME (Department of Planning, Monitoring and Evaluation) (2020) The impact of Covid-19 on South African municipalities. Survey results. URL: [https://www.dpme.gov.za/publications/Reports%20and%20Other%20Information%20Products/DPME\\_COVID-19%20Municipal%20Survey%20Results\\_June%202020.pdf](https://www.dpme.gov.za/publications/Reports%20and%20Other%20Information%20Products/DPME_COVID-19%20Municipal%20Survey%20Results_June%202020.pdf) (Accessed 3 January 2023).
- EWSETA (Energy and Water Sector Education and Training Authority) (2020) Water sector skills within a COVID-19 context. URL: [https://ewseta.org.za/wp-content/uploads/2020/12/41219\\_EWS-WISA-CONFERENCE\\_Editorial\\_rev5.pdf](https://ewseta.org.za/wp-content/uploads/2020/12/41219_EWS-WISA-CONFERENCE_Editorial_rev5.pdf) (Accessed 3 January 2023).

- FUNKE N, SCHAEFER L and LE ROUX W (2022) Notes from workshop on 'The impact of Covid-19 on water utilities in South Africa', 18 March 2022, CSIR, Pretoria.
- GUDE VG and MUIRE PJ (2021) Preparing for outbreaks – implications for resilient water utility operations and services. *Sustainable Cities Soc.* **64** 102558. <https://doi.org/10.1016/j.scs.2020.102558>
- HARA M, NCUBE B and SIBANDA D (2020) Water and sanitation in the face of Covid-19 in Cape Town's townships and informal settlements. PLAAS. URL: <https://www.plaas.org.za/water-and-sanitation-in-the-face-of-covid-19-in-cape-towns-townships-and-informal-settlements/> (Accessed 3 January 2023).
- HDA (Housing Development Agency) (2012) South Africa: Informal settlements status. URL: [http://www.thehda.co.za/uploads/files/HDA\\_Informal\\_settlements\\_status\\_South\\_Africa.pdf](http://www.thehda.co.za/uploads/files/HDA_Informal_settlements_status_South_Africa.pdf) (Accessed 3 January 2023).
- HES D (2020) A local response to Covid-19. In: Local Government Business Day. URL: [https://businessmediamags.co.za/wp-content/uploads/2020/09/LG\\_finalstrunglinked.pdf](https://businessmediamags.co.za/wp-content/uploads/2020/09/LG_finalstrunglinked.pdf) (Accessed 2 December 2023).
- HINTSA L (2022) Evaluating the impact of Covid-19 pandemic on the financial sustainability of Northern Cape local municipalities. Master's thesis, University of Stellenbosch. URL: <https://scholar.sun.ac.za/server/api/core/bitstreams/a0882df3-39a7-4008-80f0-e24a9e3600ce/content> (Accessed 13 December 2023).
- IFC (International Finance Corporation) (2020) The impact of Covid-19 on the water and sanitation sector. URL: [https://www.ifc.org/wps/wcm/connect/126b1a18-23d9-46f3-beb7-047c20885bf6/The+Impact+of+COVID+Water&Sanitation\\_final\\_web.pdf?MOD=AJPERES&CVID=ncaG-hA](https://www.ifc.org/wps/wcm/connect/126b1a18-23d9-46f3-beb7-047c20885bf6/The+Impact+of+COVID+Water&Sanitation_final_web.pdf?MOD=AJPERES&CVID=ncaG-hA) (Accessed 3 January 2023).
- MAHLALELA PT, BLAMEY RC, HART NCG and REASON CJC (2020) Drought in the Eastern Cape region of South Africa and trends in rainfall characteristics. *Clim. Dyn.* **55** 2743–2759. <https://doi.org/10.1007/s00382-020-05413-0>
- MCDONALD DA, SPRONK SJ and CHAVEZ D (2020) Public water and Covid-19: Dark clouds and silver linings. Municipal Services Project (Kingston), Transnational Institute (Amsterdam) and Latin American Council of Social Sciences (CLACSO) (Buenos Aires).
- MEISSNER R, FUNKE N, NORTJE K and STEYN M (eds) (2019) *Understanding Water Security at local Government Level in South Africa*. Palgrave-Macmillan, Cham. <https://doi.org/10.1007/978-3-030-02517-5>
- MUDOMBI S and MONTMASSON-CLAIR G (2020) Working Paper: A case for water and sanitation in South Africa's post-lockdown economic recovery stimulus. Trade & Industrial Policy Strategies (TIPS) Policy Brief 14/2020. URL: <https://www.tips.org.za/policy-briefs/item/3856-a-case-for-water-and-sanitation-in-south-africa-s-post-lockdown-economic-recovery-stimulus-package> (Accessed 3 January 2023).
- RENUKAPPA S, KAMUNDA A and SURESH S (2021) Impact of Covid-19 on water sector projects and practices. *Util. Polic.* **70** 101194. <https://doi.org/10.1016/j.jup.2021.101194>.
- RUITERS G (2020) Cape Town's crisis-ridden response to Covid-19. In: McDonald DA, Spronk SJ and Chavez D (eds) Public water and Covid-19: Dark clouds and silver linings. Municipal Services Project (Kingston), Transnational Institute (Amsterdam) and Latin American Council of Social Sciences (CLACSO), Buenos Aires.
- SERI (Socio-economic Rights Institute of South Africa) (2018) Informal settlements and human rights in South Africa. Submission to the United Nations Special Rapporteur on adequate housing as a component of the right to an adequate standard of living. URL: <https://www.ohchr.org/sites/default/files/Documents/Issues/Housing/InformalSettlements/SERI.pdf> (Accessed 3 January 2022).
- SOWBY RB (2020) Emergency preparedness after Covid-19: a review of policy statements in the US water sector. *Util. Polic.* **64** 101058. <https://doi.org/10.1016/j.jup.2020.101058>.
- SOWBY RB and LUNSTAD NT (2021) Considerations for studying the impacts of Covid-19 and other complex hazards on drinking water systems. *J. Infrastruct. Syst.* **27**(4) 02521002. [https://doi.org/10.1061/\(ASCE\)IS.1943-555X.0000658](https://doi.org/10.1061/(ASCE)IS.1943-555X.0000658)
- SPEARING LA, THELEMAQUE N, KAMINSKY JA, KATZ LE, KINNEY KA, KIRISTS MJ, SELA L, FAUST (2021) Implications of social distancing policies on drinking water infrastructure: an overview of the challenges to and responses of U.S. utilities during the Covid-19 pandemic. *ACS EST Water* **1** 888–899. <https://doi.org/10.1021/acsestwater.0c00229>
- STATS SA (Statistics South Africa) (2020) Business impact survey of the Covid-19 pandemic in South Africa URL: <http://www.statssa.gov.za/publications/Report-00-80-01/Report-00-80-01April2020.pdf> (Accessed 3 January 2023).
- WISA (Water Institute of South Africa) (2020) Covid-19: The risk the pandemic poses to SA's water supply. URL: <https://wisa.org.za/2020/06/30/covid-19-the-risk-the-pandemic-poses-to-sas-water-supply/> (Accessed 3 January 2023).
- WRF, EPA and AWWA (Water Research Foundation, Environmental Protection Agency, American Water Works Association) (2013) Business continuity planning for water utilities: guidance document. Web Report #4319. URL: <https://www.waterisac.org/system/files/Business+Continuity+Planning+for+Water+Utilities.pdf> (Accessed 30 November 2023).